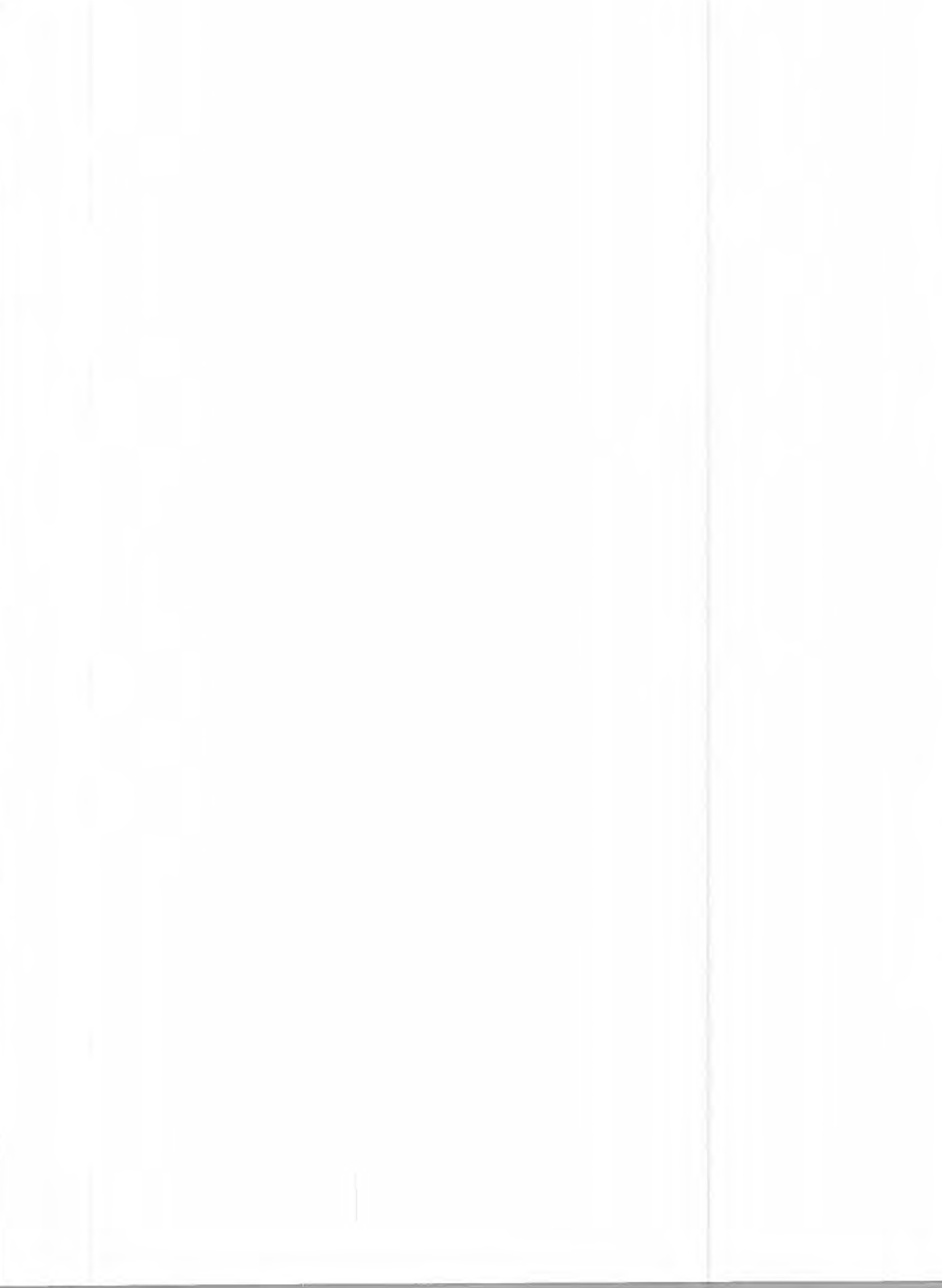




PLANT SCIENCES



PLANT SCIENCES

The Plant Sciences Division (PSD) is focusing on sustainable improvement in productivity and quality of crop commodities. Major activities towards achieving this goal includes development of improved varieties / hybrids through provision of relevant germplasm to various NARS partners, acquired locally and/or from abroad. Moreover, resistant sources were also identified using conventional as well as molecular approaches. Holding up of National Uniform Yield Trials (NUYT) of various commodity crops is one of the regular activities which provides the bases for release of high yielding varieties / hybrids resistant to various biotic and abiotic stresses. In addition to this, the report also highlights the outcome of significant studies conducted to enhance resilience in our cropping systems and to bring a sustainable increase in productivity through adoption of high yielding and disease resistant varieties/hybrids and resource efficient crop management strategies.

COORDINATION ACTIVITIES

Germplasm Acquisition and Distribution

- Following germplasm was acquired from various international sources for their evaluation and utilization in national breeding programs of various commodities.

Crop	Acquired	Distributed
Wheat	12324	12324
Rice	625	625
MSM	415	380
Sugarcane	Fuzz of 6 bi-parental crosses	-
Pulses	264	264
Oilseeds	44	75
Fodders	58	171
Fruits	-	7
Vegetables	30	57

Meetings

- Meetings of Variety Evaluation Committee (VEC) on rice, wheat, maize and oilseed crops were held in which potential candidate lines were evaluated and those found promising were recommended to be released for commercial cultivation.

- Annual Wheat Planning Meeting was organized in conjunction with WPEP-Annual Review. All the WPEP partners and national and international partners attended this meeting to discuss their ongoing activities and future plan of work.

National Uniform Yield Trials (NUYT)

- Nuyts of following crops were conducted to find out the suitable entries and to move forward with their commercialization

Crops	Entries	Locations
Wheat	40	53
Rice (Hybrids / Coarse / Fine)	70/8/12 = 90	15
Maize	135	39
Sorghum	22	3
Sorghum (Fodder)	7	9
Millet	10	5
Millet (Fodder)	8	9
Sugarcane	8	4
Lentil	12	17
Chickpea	29	30
Mungbean	17	15
Mash	5	12
Oilseed (6 crops)	8-26	4-18

WHEAT

Germplasm Development and Evaluation

- Based on two years' performance in NUYT, the advance line NR-399 is recommended by the Expert Sub-Committee of the Punjab Seed Council and Variety Evaluation Committee of PARC for commercial release. With desirable quality traits, NR-399 carries desirable resistance against Yellow rust (Yr), Leaf rust (Lr) and Stem rust (Sr) (local and Ug99 races) and is proposed to be released with a name Borlaug 2015 for rainfed and irrigated ecologies of Pakistan.
- A high Zn containing advance line NR-421 has been recommended by VEC and experts of sub-committee of Punjab Seed Council for release as commercial variety for irrigated ecology of Pakistan with a proposed name of Zincol 2015. The advance line exhibited higher accumulation of Zinc in grains (38 ppm as compared to the 25 ppm of composite local check) and carries desirable resistance against Yr, Lr and Sr.
- During 2014-15, 420 new crosses were made for drought tolerance, disease resistance and quality improvement.
- 1232 segregation populations at different filial generations were harvested at NARC whereas, 969 populations were planted at SARS Kaghan for generation advancement.
- 1040 F6 head rows (104 populations) were planted at NARC and 102 head rows were selected for further evaluation.
- Six observation nurseries and 11 yield trials comprising of 1477 test entries, were assessed for yield potential and other traits of economic importance. 328 lines selected for further analysis.
- Six observation nurseries consisting of 1052 entries were evaluated for various parameters. 242 lines were selected for further evaluation in preliminary yield trails
- 24 top yielding lines from Advance Yield Trials (AYT) were selected for testing



Figure-1 Development of Recombinants

in multi-location trials and for screening in National Wheat Disease Screening Nursery (NWDSN) against diseases of economic importance.

- Based on the performance at various stages of testing, four bread wheat advance lines were contributed for testing in the National Uniform Yield Trials (NUYT).
- For replacement of existing commercial varieties vulnerable to new races of Sr and Yr, popularization of new resistant varieties (Pakistan 2013 on 31 acres) is being done through demonstration and provision of seed [Pakistan 2013 (100 acres), NARC 2011 (13 acres), NARC 2009 (123 acres)]. Moreover, 100 acre seed production blocks of wheat variety Pakistan 2013 has been planted through National Rural Support Program (NRSP).
- 2000 kg seed of NARC 2009, 6500 kg seed of NARC 2011 and 6000 kg seed of Pakistan 2013 have been supplied to WPEP for production of certified category of seed over an area of 290 acre

Crop Management Strategies

- For fertilizer management, a trial was conducting on 06 different sites (*village Dhok Lass Tehsil Kallar Sydian, village Sukhuu, Tehsil Gujar Khan, village Kurri District Islamabad, village Sulkaither Tehsil Murree, village kamil pur District Attock and NARC Islamabad*) in the high rainfall area of Potohar using wheat variety *Pakistan-2013* with the seed rate of 50kg/acre. The study indicated that 80 kg nitrogen/ha is sufficient for soils having sufficient quantity of phosphorous while those soils which are poor in phosphorous, 60 kg/ha phosphorous along with 80 kg nitrogen/ha is adequate to get the optimum yield from these soils.
- For popularization among the farmers of abovementioned areas, of Mung bean – wheat cropping system was demonstrated in comparison of Fallow –Wheat, Maize – wheat and Millet-Wheat cropping systems. Over all, maximum grain yield of wheat (3.8 t/ha) was recorded in case of Mung bean-Wheat cropping system. In terms of sustainability and net benefit return per annum, Mung-Wheat cropping system proved to be more profitable and sustainable cropping system under high rainfall zone.
- For quick adoption of ridge planting method for wheat, demonstrations were made at 9 different locations in the Rice-Wheat area of Punjab by sowing wheat variety *Pakistan-2013* at seed rate of 50kg/acre. These sites include *Muneer Farm Murid Key, Shehbaz Farm Murid Key, Village Jalhar Bhattian District Sheikhupura, Village Nakay Wal Bosal District Mandi Baha-Ud-Din, Village Bhatti Chack District Hafiz Abad, Village Pandori Kallan District*

Gojranwala, Mushtaq Cheema Farm Village Baigowal District Sialkot, Ch. Farooq Farm Village Baigowal District Sialkot and Village Langay District Sialkot. Statistically at par grain yields were recorded in case of ridge planting of wheat as compared with the conventional Broadcast method. However, adoption of ridge planting can be helpful in saving the irrigation water up to 30-40% and energy on large scale.



Figure-2 Ridge planting of wheat

- Introduction of berseem in rice-wheat cropping system produced higher grain yields (5.3%) as compared to continuous adoption of rice-wheat cropping system. This integration has been demonstrated at 10 different sites on farmers' fields in the rice-wheat area of Punjab (*Muneer Farm Murid Key, Liaqat Ali Bhatti Farm Murid Key, Village Jalhar Bhattian District Sheikhupura, Village Nakay Wal Bosal District Mandi Bahauddin, Village Chack Bhatti District Hafizabad, Village Gagay Wali District Gojranwala, Mushtaq Cheema Farm Village Baigowal District Sialkot, Ch. Farooq Farm Village Baigowal District Sialkot, Village Langay District Sialkot and Village Porab, District Sialkot*). Owing to the potential advantages (*enhances the soil fertility, reduces the weed germination*), this adaption of Berseem-Rice-Wheat rotation is economically favorable and environment friendly.
- Farmer's Field Days were conducted at 7 different sites (5 in Rice –Wheat area and 2 in Potohar region) of Punjab regarding the promotion of wheat sowing on ridges, integration of Berseem in Rice-Wheat rotation and promotion of Mung bean-Wheat cropping system. The details are as under:

Site	Date	No of participants
Langay Tehsil Pasroor District Sialkot	18-3-2015	60
Baigowal Tehsil Sumbrial, District Sialkot	19-3-2015	65
Pandori Kalam, Tehsil Wazirabad, District Gojranwala	22-3-2015	162
Jalhar Bhattian (Feroze Pur Watwan District Sheikhupura)	25-3-2015	125
Bhatti Chack District Hafizabad	27-3-2015	138
Sukhuu Tehsil Gujar Khan	2-4-2015	97
Dhoke Lass, UC Dobairan kalan Tehsil Kallar Syedan District Rawalpindi	22-4-2015	120

RICE

Germplasm Development and Evaluation

- For development of indigenized hybrids through ABR line system, eight sets of elite lines/varieties were converted into CMS lines through backcross breeding technique. The process of backcrossing will be continued (up to BC6) till the stable CMS lines would be developed. Restorer plants were self crossed for the purpose of genetic purification. The process of selection and selfing will be continued till the desired restorer lines are developed.
- Thirty six accessions of rice collected from gene bank of PGRI, NARC were evaluated for development of low-water requiring rice varieties for their Direct Dry Seeding. 12 accessions were selected for further studies.

Crop Management Strategies

- Weeds being considered as one of the main obstacles for adoption of direct dry seeding of rice-cultivation technology by the rice growers in the country. So various trials were conducted for effective weed management. These include:
 - **Pre-emergence weed management:** The pre-emergence herbicide "Click" was tested with varying doses (600, 900, 1050). Pre-emergence application of Click @ 900 ml/ha was found suitable for weed control and higher returns.
 - **Selection of post emergence herbicides:** Four weedicides (*Clover*, *Pyranex Gold*, *Parsal*, *Eradicate*) with two application rates (250 & 375 g/ha) of each weedicide were investigated. Application of Pyranex Gold @ 375 g/ha and Eradicate @ 250 g/ha were found to be the most effective for weed management.
- For estimation of optimum fertilizer in Direct Seeded Rice, NPK treatments (100-60-60, 120-70-65, 140-80-70, 160-90-75, 180-100-80) were applied with other recommended crop management strategies. Results revealed that plant height and number of productive tillers/m² increased with enhancing fertilizer rates. Paddy yield increases with increasing fertilizer rates up to a certain level and then a decrease was noted. The decline in yield may be due to crop lodging because of taller plants and soft stems in higher fertilizer rates. The maximum average paddy yield (3.24 t/ha) was recorded from 140-80-70 NPK kg/ha
- To determine suitable plant spacing, an experiment was conducted with 25x10, 30x10, 22.5x22.5, 20x15, 25x15, 30x15, 20x20, 25x20 and 25x25

cm spacing. Data revealed that maximum paddy yield was achieved with 25x10 cm spacing.

- Demonstration of direct sowing of rice was performed at Sadhoki Site Gujranwala to popularize this technology in the area. Proper plant protection measures were taken during growth period of the crop. DSR plots were managed at different farms including Abdul Shakoor, Riasat, Riaz, Arshad, Sabir and KSK farm. Paddy yield with different establishment methods at all sites varied between 3.03 to 5.25 t/ha. Average maximum paddy yield (4.03 t/ha) was obtained from broadcast method followed by drill sowing (3.90 t/ha) and conventional transplanting (3.74 t/ha).

SUGAR CROPS

Germplasm Development and Evaluation

- A total of 189 indigenous and exotic sugarcane genotypes are being maintained for flowering study and fuzz collection at the Makli experimental farm, Thatta. During 2014, a total 15 kg local fuzz of different sugarcane varieties was collected from **National Sugar&Tropical Horticulture Research Institute (NSTHRI)**, farm Thatta



Figure-3 Sugarcane fuzz preserved for distribution in sugarcane breeding programmes

- and the adjoining coastal areas. The collected fuzz is stored in deep freezer for distribution to sugarcane scientists/institutes for their breeding programmes.
- Out of 5248 seedlings obtained from sugarcane fuzz in nursery, 2500 seedling clones were transplanted to the main field in single clone trial for further evaluation and selection. Out of 2500 seedlings, 417 genotypes from single plants, were promoted and sown in first cycle for further evaluation and selection.

- Cane yield and quality performance of different sugarcane lines was tested in National Uniform Yield Trials (NUYT) plant crop during 2013-14 at Makli farm. The data revealed that Chinese sugarcane lines YT-53 exhibited maximum cane

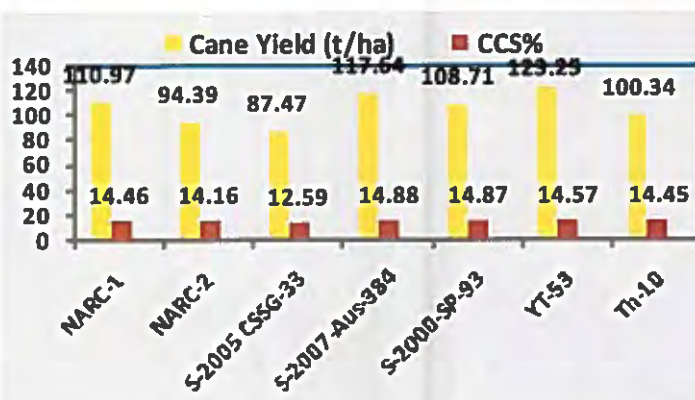


Figure-4 Performance of sugarcane genotypes tested in NUYT 2013-14

yield (123.25 t/ha) followed by S-2007-Aus-384, NARC-01 and S-2000-SP-93 with cane yield of 117.64, 110.97 and 108.71 t/ha respectively against the check variety Thatta-10 (100.34 t/ha). In case of quality, sugarcane lines S-2007-Aus-384, S-2000-SP-93, YT-53 and NARC-01 produced Commercial Cane Sugar (CCS) of 14.88, 14.87, 14.57 and 14.46%, respectively against

the check variety Thatta-10 (CCS 14.45%).

- In vitro propagation of sugarcane varieties viz. Th-300, YT-53 and YT-55 were initiated. For multiplication and rooting, kinetin was used as the shooting hormone instead of BAP. During the reporting period, 8563 sugarcane shoots were initiated and 4140 were shifted on rooting and 3714 on hardening. The survival rate was 79% (2934 plants). Out of these, 200 plants were sown on field a progressive grower Mir Wali Muhammad Talpur, Digri, district Mirpurkhas. The process of shifting the remaining plants on growers' field is being carried out.
- NUVYT 2012-14 (2nd plant crop): Cane yield and quality performance of different sugarcane lines was tested in NUYT second plant crop during 2013-14 at Makli farm. The data revealed that Chinese sugarcane variety YT-55 exhibited maximum cane yield (119.19 t/ha) followed by S-2005 CSSG-32 and BPTH-804 with cane yield of 107.99 and 104.33 t/ha, respectively against the check variety Thatta-10 (101.20 t/ha). In case of quality, the data in Fig-5 revealed that sugarcane lines YT-55, BPTH-804, S-2006 SPSG-29, S-2005-HoSG-31 and S-2006 SPSG-27 produced CCS of 13.28, 12.78, 12.50, 12.48 and 12.45 against the check variety Thatta-10 which produced CCS of 12.10%.

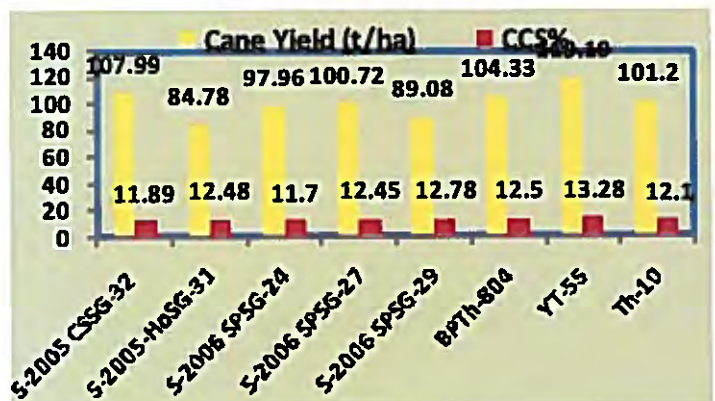


Figure-5 Performance of sugarcane genotypes tested in NUYT 2012-14

Crop Management Strategies

- Application of plastic film as mulch on already planted sugarcane variety BL-4 at Makli agriculture farm, Thatta revealed maximum germination (72%), while in control plot (No mulching) 60% germination was observed. Maximum cane yield of 297 t ha⁻¹ was observed in plastic mulched

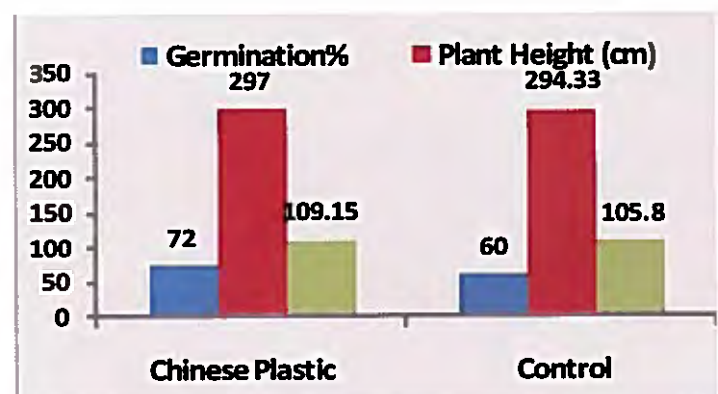


Figure-6 Effect of Chinese plastic mulching on sugarcane growth and yield

plots, while in control plot 294 t ha⁻¹ cane yields was observed. The good germination ultimately contributed in good crop stand in plastic mulched plots therefore, increase in cane yield and yield parameters was observed. The efforts were made to manufacture the plastic film locally and small quantity of the film roles were tried with comparatively thicker film. Both the plastic films were applied in sugarcane at farmer's field for evaluation. However, the expected results were not achieved, as sugarcane did not penetrate through the locally manufactured film but it has same effect on soil moisture retention, soil temperature and germination.

- Single budded sets of 30 sugarcane genotypes developed by NSTHRI, Thatta were inoculated by adopting standard procedure of dipping in an aqueous teliospore suspension of 10⁶ spores/ml. Single line (7 m) of each variety was planted in triplicate under RCBD during 2013-14 at NSTHRI, Experimental Farm Thatta. Out of 30 sugarcane genotypes, only 02 genotypes namely QSSG-1741 and YT-236 were noted highly susceptible (HS) with 37.66 and 35.88% infection respectively. While, the genotypes CSSG-2476, S-2003-US-694, CSSG-2402, Triton, S-2002-US-133 and HoTh-547 were noted susceptible (S) with 23.75, 22.50, 18.33, 17.33, 16.37 and 16.25 % infection respectively. The genotypes SPSG- 1663, HoTh-607, HoTh-544 and CPD-01-243 were declared moderately susceptible (MS) with 7.66, 7.33, 5.66 and 4.66% infection respectively. Moreover, the genotype HoTh-514, BPTH-807 and CPD-01-346 were noted moderately resistant (MR) with 3.66, 2.66 and 2.33% infection respectively. However, the rest other 14 genotypes in the trial were found resistant (R) to whip smut disease when inoculated before planting.

OILSEEDS

Germplasm Development and Evaluation

- One hundred and twenty single plants (A, B and R) were planted during spring, 2014 and selected nine uniform single plant progenies of CMS (A) and maintainer (B) lines. In addition to this, 100 A and B single plants were also selected from different A and B lines. Similarly, in R (fertility restoring) line, nine uniform single plant progenies were selected and seed was bulked. Moreover, 24 single plant selections from different progenies were also maintained as individual plant selections. In autumn 2014, 109 A, B and 33 R lines were planted in head to row and selected 40 and 22 plants in A/B and R lines respectively.
- Thirty six **sunflower** inbred lines were planted for maintenance, purification and generation advancement purpose. 129 new inbred lines in different developmental stages were planted for selfing and backcrossing to CMS source for putting them in CMS background. 34 new hybrid combinations were made using different CMS and R lines.
- Fifty three local, eighteen exotic and two standard checks (Hysun-33 and NK-S-278) were evaluated in four different trials at NARC. Local hybrid SMH-0917 produced maximum seed yield of 3868 kg/ha followed by PARSUN-3, SY-4045, Hysun-204 and SMH-0909 with 3838, 3724, 3699 and 3684 kg/ha respectively. During autumn-2014, SMH-0927 produced the highest yield of 1994 kg/ha followed by SMH-0917, Hysun-33, SMH-0925 with 1905, 1864 and 1861 kg/ha, respectively.
- Out of 20 **mustard** lines, cross BRJ-04012 X Dune Black produced maximum seed yield of 2303 kg/ha followed by BARD-1 (2185 kg/ha) and Khanpur Raya (2133 kg/ha).
- Out of 14 promising **rapeseed** lines, check variety *Punjab Sarson* produced maximum seed yield of 2929 kg/ha followed by SPS-28-25 (2803 kg/ha) and SPS-29-32(2763). Over all, 9 lines produced more seed yield than the other check variety Faisal canola (2584 kg/ha).
- In F3 generations desired 21 crosses were sown and uniform, high yielding **groundnut** lines were selected. In F4 Generations desired uniform family rows of 9 crosses were sown. Data on dry pods yield varied from 80 gm (BARD-92xPG-1053, P6) to 320 gm (PG-1058xPG-668, p5) and days to 50% flowering ranged from 34-41 were recorded.

- Twelve promising groundnut entries were evaluated in preliminary yield trials. The highest dry pods yield of 4015 kg/ha was recorded in PG-1242 followed by entries PG-1244 and PG-1245 with yield values of 3843 and 3551 kg/ha, respectively. Entry PG-1214 had the lowest dry pods yield of 1535 kg/ha.



Figure-7 Promising groundnut germplasm

- Twelve promising groundnut entries were evaluated in advance yield trial. The maximum dry pods yield 4248 was recorded in PG-1163 followed by PG-1246 and PG-1192 with yield values of 4143 and 4057 kg/ha, respectively. Entry PG-1191 had the lowest dry pods yield of 2407 kg/ha.
- Sixteen entries of International Confectionery Groundnut Yield Trial received from ICRISAT were evaluated at NARC. Highest dry pods yield of 3629 kg/ha was recorded in PG-1196 followed by PG-1211 and PG-1170 with dry pods yield of 3543 and 3401 kg/ha, respectively. Entry PG-1188 had the lowest dry pods yield of 2120 kg/ha.
- The evaluation of **sesame** germplasm revealed that the mean seed yield of 211 sesame genotypes was 227 kg/ha with a range of 116 kg/ha to 533 kg/ha. Check TS-3 produced seed yields of 142 kg/ha. One hundred and seventy-four genotypes produced better seed yield compared to TS-3 with range of 147 to 533 kg/ha.
- Seed yield of 55 linseed entries ranged from 673 kg/ha (LS-34) to 2567 kg/ha (LS-55) with mean value of 1513 kg/ha. Twenty-four accessions out yielded the check (1533 kg/ha) producing yields ranging from 1547 to 2567 kg/ha. In Preliminary Yield Trial, seed yield of 10 entries ranged from 1478 kg/ha (LS-32) to 1811 kg/ha (LS-4) with mean value of 1613 kg/ha. Eight genotypes viz. LS-4, LS-24, LS-19, LS-50, LS-12, LS-25, LS-14 and LS-43 produced more seed yield compared to check (1506 kg/ha) with respective yield values of 1811, 1800, 1689, 1594, 1578, 1567, 1567 and 1539 kg/ha. **Advanced Yield Trial:** Seed yield of 10 entries ranged from 1200 kg/ha (LS-40 and LS-48) to 1867 kg/ha (LS-1) with mean value of 1528 kg/ha. Four genotypes viz. LS-1, LS-35, LS-16 and LS-27 produced seed yields of 1867, 1722, 1689 and 1644 kg/ha respectively compared to check with seed yield of 1567 kg/ha.
- In the Preliminary Yield Trial of soybean, seed yield ranged from 366 to 1273 kg/ha. Maximum seed yield was recorded in E-788 (1273 kg/ha) followed by

536-2D with seed yield of 1226 kg/ha. Minimum seed yield was recorded in entry William-82 (486 kg/ha). 10 entries were evaluated in Advanced Yield Trial, at NARC. Seed yield ranged from 980 to 1406 kg/ha. Maximum seed yield was recorded in Lochlon (1406 kg/ha) followed by Amcor with seed yield of 1280 kg/ha. Minimum seed yield was recorded in entry Callend (980 kg/ha).

Crop Management Strategies

- Results of a trial to study the effect of NPK Fertilizer on Short Duration Variety PG-1058 showed that the highest dry pods yield of 2343 kg/ha was obtained in treatment that received NPK (20-80-50 kg/ha) followed by treatment that received NPK (30-80-100 kg/ha) with dry pods yield of 2294 kg/ha. The lowest yield 1799 kg/ha, obtained in control treatment. Different doses of NPK had significant effect on yield.
- Following field days were organized to create awareness among the growers:
- *"PARC Canola Field Day"* on 11-03-2014 at NARC.
- *"PARC Canola Field Day"* on 29-04-2014 on farmer's field at Langah Village, Chakwal.
- *"Soybean Field Day"* on 20-10-2014 at NARC.
- Visit of Soybean Field for 200 farmers on 06-11-2014 with the collaboration of Lok Sanjh for creating awareness about the importance of soybean and its promotion.
- Four soybean varieties were planted for seed production during Kharif 2014 on 224 acres at NARC, Islamabad and an estimated quantity of 50 ton seed was produced.

Varieties	Estimated Seed Production (kg)
NARC -II	9530
William -82	9300
Ajmeri	21050
Rawal -1	10244
Total	50124

Oil Quality

- A total of 147 samples of different groundnut experiments were analyzed for oil content which ranged from 46 to 56 % with mean value of 52%.

PULSES

Germplasm Development & Evaluation

Mungbean

- Seventy mungbean germplasm were evaluated for Mung Yellow Mosaic Virus (YMV). Three accessions, namely MSPS107, MSPS124 and 14165 have been found resistant to YMV. Six genotypes showed moderate resistance. Moreover, fourteen exotic accessions of mungbean were also evaluated for bruchid (*Callosobruchus maculatus*) resistance and 3 were found to be resistant. These genotypes were used in crossing with four varieties with high yield and well adapted but susceptible to bruchid.



Figure-8 Crossing block of bruchid resistant breeding in mungbean at NARC

- In adaptation trial on mungbean 18 genotypes were tested out of which 3 genotypes were found high yielding. These genotypes will be evaluated in NUYT's.
- Mungbean National Uniform Yield Trial, comprised of 17 elite lines and 3 checks, was conducted at 15 locations. Genotype BRM-311 across the locations produced highest mean grain yield of 1028 kg/ha than checks.



Figure-9 Advancement of F2 segregating populations

Mashbean

- Twenty two mash bean germplasm accessions were evaluated for YMV resistance under field conditions during the kharif season of 2014. Out of which 7 genotypes were found tolerant to MYMV while the rest of the genotypes were susceptible. In preliminary trial 40 genotypes of mashbean were evaluated and 22 genotypes were selected having erect plant type, early maturity and bold

seed size for further evaluation in advance yield trial. Twelve genotypes of mashbean were selected from advance yield trial for further evaluation in adaptation trials and three promising genotypes were selected for testing in NUYT.

- National Uniform Yield Trial comprised of five elite lines of mashbean and one check variety was conducted at 15 locations. Combined analysis of variance revealed that the differences among the genotypes, location and genotype x environment interaction were highly significant for grain yield. Genotype Mash-010-1 produced highest mean grain yield of 741 kg/ha across the locations than the check variety. This genotype was contributed by pulses program and further evaluation for variety release from VEC is in progress.



Figure-10 *Mash genotypes with erect plant types tested at NARC*

Chickpea

- One hundred and fifty five chickpea germplasm accessions were evaluated for blight resistance under field conditions during 2013-14. Out of which 17 lines were found resistant to Ascochyta blight.
- Five cross combinations involving six parents with targeted traits i.e. Blight resistance, bold seed size, erect plant type were attempted and two combinations were found successful. Also fifteen segregating populations from F_5 to F_8 were enhanced to attain homozygosity in chickpea genotypes.
- The results of National Uniform Yield Trial (NUYT) on Desi and Kabuli chickpea showed a wide range of variation for grain yield between locations and varieties. In Kabuli NUYT, genotype CM770/06 gave higher mean grain yield of 1855 kg/ha as compared to the check Noor-09 (1792 kg/ha) across 9 locations. Two lines NCS-0610 and NCS-0612 contributed by the Pulses program NARC were prominent



Figure-11 *Chickpea genotypes showed blight resistance*

and are being further evaluated to complete the processes of variety approval.

Lentil

- Thirty five segregating populations of lentil from F2-F7 were enhanced to attain homozygosity. While 34 mutants were evaluated for post-emergence herbicide tolerance and 25 single plant selections were made from M12 to generate plant rows and to use these homozygous lines in the preliminary yield trial. In Lentil Adaptation Trial, 28 genotypes were tested and based on maturity time and seed yield 18 genotypes were selected for further studies.

Crop Management Strategies

- Under RADP Sub-project *"Seed production and popularization of lentil variety, Markaz-2009"*, the variety with complete package of production technology was introduced and demonstrated on 20 sites in five districts of Pothwar region and its adoption rate is 44% in the study area. During the two field days, *organized at NARC and at Village Aara Sural, Tehsil Sohawa District Jehlum*, farmers shared their experience of growing Markaz-09 and the resultant increase in average yield from 3 to 15 mounds/acre.



Figure-12 Lentil Field Day

- Under AIP/AVRDC sub-project *"Improved Mungbean Production"*, mungbean is being introduced as a part of double cropping in wheat-fallow areas of Pothwar Region. During 2014, the demonstration plots were planted on an area of 19.6 ha at selected sites in 3 districts (Islamabad, Rawalpindi and Attock). Farmers were supervised for adoption of complete package of production technology. Brochures about package of production technology were distributed for the guidance of the farmers. A field day was also



Figure-13 Field Day for mungbean popularization

celebrated in district Attock in which 200 farmers participated.

- For mechanical harvesting of mungbean different chemical desiccants were evaluated to dry the mungbean crop for combine harvesting. The chemical Paraquat was found most effective in drying crop within 4-5 days of application. Paraquat spray was applied on mungbean seed production blocks planted on 12 acres at NARC. Small combine harvester (heigy) was used for combine harvesting of mungbean. For combine harvesting of mung on larger area multi-crop large combine machine was tested at NARC and it was found successful.



Figure-14 Mungbean crop with and without desiccant application

MAIZE SORGHUM MILLET & FODDER

Germplasm Development & Evaluation

- Maintenance, Purification and multiplication of indigenous Sorghum Sudan hybrids (*NARC Hybrid-2 and NARC Hybrid-4*) was done for commercial production of seed to ensure availability and timely sowing of well adapted local hybrids at cheaper price.
- Thirteen sorghum cytoplasmic male sterile (A) and male fertile (B) counterparts were maintained, multiplied and purified by sowing with a ratio of 1:2:1 (B:A:B). Heads of both sorghum A and B lines were harvested separately at physiological maturity. Specific and general combining ability studies of these lines will be carried out along with different restorer lines (Sudangrass) to identify new high biomass yielding combinations.
- 150 genotypes of millet, 107 of sorghum and 20 of sudangrass were sown under rainfed conditions of Islamabad with the application of recommended dose of fertilizers. True to type heads of each entry were harvested to get pure seed at physiological maturity.
- Oats germplasm (170 entries/genotypes available with the fodder program and 100 accessions from Gene bank of PGRI, NARC) was evaluated under field conditions and found highly diversified for traits of economic importance. Weight gain rate ranged from -6.25 to 135.42 grams/day. Forty (40) genotypes were gaining above 72 grams of green matter per day. Genotypes having negative or very less weight gain would be better for earlier fodder production (short duration). These genotypes will be re-evaluated under augmented design for the second year. On the basis of two years evaluation, higher green fodder yielding genotypes will be further tested under preliminary, advanced and national uniform yield trials.
- Thirty entries of barley and fourteen entries of vetch were maintained and multiplied to get pure seed for future research purposes and dissemination to collaborators.
- In Preliminary Fodder Yield Trial on Oats, maximum green fodder yield of 81.48 t/ha was observed for "Oats-Sel-1", followed by check variety "NARC-Oats" (with green fodder production of 80.09 t/ha). The trials comprised of fourteen promising oats genotypes (*No.1xS-81, No.677-Sel, No.663, CK-1, Caraville, Coronado, Athabasca Sel, ESK-Sgd, Oats-Sel-1, Forkdeer Sel, No.9217604 and Canadian and two checks (Pd2Lv65 and NARC-Oats)*).

- In National Uniform Fodder Yield Trials, a promising oat genotype 'No.97009' contributed by Fodder Research Programme, NARC was found at par (regarding green fodder production) with an approved variety "NARC-Oats". Their green fodder production is 66.05 t/ha and 66.36 t/ha respectively.
- The introduction and demonstration of approved varieties of Rabi and Kharif fodder crops (*oats, berseem, lucern, mott grass, SS hybrid, maize, millet and guar*) was done under Agricultural Innovation Program (AIP) – ILRI component and CRP 1.1 – ICARDA component. The purpose was to replace the old/obsolete, low yielding varieties through research based interventions and (VBSEs) *Village Based Seed Enterprises*. These VBSEs will not only help to provide seed to farmers at their door-step but also bring sustainable enhancement in productivity of fodders.



Figure-15 Introduction and demonstration of improved fodder varieties

Crop Management Strategies

- An experiment entitled "Nitrogen optimization through LCC in maize" was conducted in triplicate using seven nitrogen levels (control, 60, 120, 180, 240, 300, and 360 kg/ha) and four cultivars (KYM-9012, NARC 2704, Islamabad Gold, Petal 5800). Data collection was started at six leaf stage using chlorophyll meter and LCC at ten days interval. The results varied significantly at different nitrogen levels indicating progression in yield for every increase in Nitrogen level.



HYBRID SEED

Research Highlights

Hybrids of major field and horticultural crops (*Cotton, Oilseeds, Maize, Rice, and Vegetables*) are being developed and promoted to the farmers on affordable price. The hybrid seed produced indigenously is being commercialized through Public-Private collaboration. The alient progress made by various components is summarized as below:

- The Oilseed Research Program has developed the local **canola** hybrid "PARC Canola Hybrid" and it is recommended by VEC (Variety Evaluation Committee) PARC for approval in September 2014. The PARC Canola Hybrid seed production block was planted at NARC on 70 acres. F1 hybrid seed (CMS) of about 20 tons was produced.



Figure-16 Field view of canola hybrid seed production

- The local **sunflower** hybrid SMH-907 have been developed and approved by VEC (Variety Evaluation Committee) PARC. It has potential yield of 4000 kg/ha. For its hybrid seed production, the seed multiplication of inbred line was done on 2.5 acre at NARC during autumn 2014. The total 100 kg seed CMS was produced.



Figure-17 Field view of SMH-907

- Hybrid seed production blocks to produce white **maize** hybrid "NARC-2704" were sown on 15 acres at NARC during July 2014 and 3800 kg hybrid seed was harvested.



Figure-18 NARC-2704 growth & development

- Eight sets of CMS plants were backcrossed to elite lines/varieties of rice (BC3). The varieties/lines used as male parents included IR-6, IR-9, KSK-282, KSK-133, RSP-3, RSP-4, IR-72 and IR-83142. Restorer plants selected from segregating populations of commercial rice hybrids viz RH-200, RH-205 and RH-225 were advanced to F5 generation and restorer plants selected from hybrids Guard-53 and Pokhraj were advanced to F6 generation.



Figure- 19 Back crossing of Rice CMS lines in the isolation cages

- Indigenously developed chilli hybrids performed better regarding green chilli yield in comparison to two local varieties i.e; Tatapuri (18.35 T/ha) and Lounghi (16.55 T/ha). The hybrids also performed better with green chilli yield of Hyb.2-13 (140.15 T/ha), Hyb.4-13 (127.65 T/ha), Hyb.10-13 (114.75 T/ha), Hyb.1-13 (110.3 T/ha) as compared to two international hybrids i.e; 222-hybrid (52.20 T/ha) and HP.No.17 (118.75 T/ha).



Figure- 20 Best performing hybrid (Hyb 2-13 yielded 140 t/ha)

- In June 2014, Brinjal fruit to row progenies of successful self fruits of 157 in S_2 (after 2nd selfing cycle) were transplanted for further selfing. From the 157 progeny rows; 39 fruits (S_3) were selected.
- Genetic improvement through hybridization was carried out in pea for variety development. Four fresh cross combinations (F_0) were developed and five pea (F_1) were selfed to F_2 .



Figure-21 Selfing methodology in Brinjal

- 10 BC-4 were made in cotton for conversion of local material into CMS for Development of A, B, and R System. For Combining ability Study 8 parental Partial diallel hybridization was done.

BANANA

In vitro Propagation

- In vitro propagation of various banana varieties like B-10, W-11, Pisang, G-9 and local variety Basrai were carried out at NSTHRI, Thatta. For multiplication and rooting of banana, MS media of Phyto Tech Company was used in addition with sugar, KH_2PO_4 , ammonium tartrate with various doses of shooting and rooting hormones (BAP, IAA and IBA). During the reporting period, 44277 shoots were maintained in laboratory and 9691 shoots of those were transferred on rooting. About 13778 rooted plants including 4000 received from NARC were put on hardening and alive a number of 11678 plants with 85% survival rate. Out of total survived, 4200 plants were shifted on field of progressive growers in Sindh namely; Mr. Abdul Majeed Nizamani (Tando Muhmmad Khan), Mr. Niaz Muhammad Nizamani (Tando Allahyar), Syed Shabir Ahmed Shah Rashdi (Tando Allahyar), Mr. Mahmood-ul-Hassan Dars (Tando Allahyar), Mr. Jan Muhmmad Keerio (Shaheed Benazir Abad), Syed Ameer Hyder Shah (Thatta), Mr. Ghulam Sarwar Abro (Kotri) and Mr. Abdul Hakeem Baloch (Thatta). The tissue culture plants were also provided to different research institutes for testing like CDRI-SARC, Karachi; ARI, Tandojam and HRI, Mirpurkhas.



Figure-22 Banana plants in PP bags.



Figure-23 TCL at SARC, Karachi

Evaluation of Chinese Banana Cultivars

- A total of 4200 plants were shifted on field of progressive growers in Sindh for evaluation purposes. The growers (including Mr. Abdul Majeed Nizamani (Tando Muhmmad Khan), Mr. Niaz Muhammad Nizamani

(*Tando Allahyar*), Syed Shabir Ahmed Shah Rashdi (*Tando Allahyar*), Mr. Mahmood-ul-Hassan Dars (*Tando Allahyar*), Syed Ameer Hyder Shah (*Thatta*) and Mr. Abdul Hakeem Baloch (*Thatta*) were satisfied with the performance especially B-10 and W-11 varieties.

TEA & HIGH VALUE CROPS

Tea

- In a field experiment the effects of different levels of organic fertilizer (Hs-organic fertilizer) on the yield and growth characteristics of tea (*Camellia sinensis* L.) variety Qi-man were investigated. Maximum fresh leaves yield (3328kg/ha), made tea (667kg/ha) and increase in shoot length (52.33cm) were recorded with the application of fertilizer @ 5350 kg/ha.
- The effect of different levels of organic fertilizers on the growth of young tea plants (variety, Turkish) was assessed. The textural class of the area was supportive for the good growth of tea crop and a gradual increase in the organic matter content and a decrease in soil pH were observed.
- Experiment was conducted to study the response of tea to drought conditions. The results indicated that height mean values (47 cm) and leaf moisture (54 %) were significantly affected by different planting dates (climatic condition). However, growing conditions and interaction between them was non-significant. The effect on leaf wilting (41 %) and growing conditions interaction was found significant.
- Surveyed 50 acres area in Union council Sum, Battal, Khaki and Tanawal for tea plantation under ALP project "*Participatory Development of Tea Value Chain around Mansehra Areas*". Planted 10,000 tea plants of Variety Qi-men at Sum, 5,000 plants at Khaki and 600 plants at Tanawal Khanan, Oghi.

Fruit Crops

- Effects of sowing methods and seed weight on the growth of walnut (*Juglan regia*) seedlings were investigated. The results indicated that raised bed cultivation gave better results regarding seedling growth whereas, the seedlings growth was found positively correlated with increased seed weight.
- Effect of different seed sowing times (10th Nov., 25th Nov., 10th Dec., 25th Dec. and 10th Jan) and single seed weight (1g, 2g, 3g and



Figure-24 Fruit plants in the field at NTHRI, Shinkari

4g) on the performance of peach (*Prunus persica*) seedlings was investigated and it was recorded that plant height (88.30 cm), stem diameter (1.80 cm), root length (25.12 cm), number of lateral roots (30.20), root diameter (1.40 cm), fresh shoot weight (120.65 g) and root weight (90.30 g) was highest in plants raised from 3g seeds sown on 10th November.

- True to type nursery plants (13300) of hilly fruit species were produced at NTHRI. 5000 fruit nursery plants were provided to the growers and Agric. Institutes.
- The survival rate of kiwi seedlings, imported from Nepal through HRI NARC Islamabad, was 83% and the growth of the kiwi plants was vigorous. To promote the kiwi fruit in Mansehra area, more than 300 seedlings were raised at NTHRI. Moreover, 16 kiwi seedlings were also planted on farmer field.



Figure- 25 Mother fruit orchard at NTHRI, Shinkiari

- Managed the Mother Fruit Orchard and installed Drip Irrigation System for production of true to type nursery plants.

Vegetable Crops

- Efforts were initiated to refine and improve the production technology of various vegetables under the climatic conditions of Mansehra. Following activities were conducted for this purpose:
- *Screening of pea genotypes for yield and disease resistance:* Based on results, it is recommended that pea variety 'Climax' is the most suitable for this area. The performance of advance lines PF-400, pointed towards its utilization in future breeding programs.
- *Nutrient management in tomato:* to find out the most effective and economical fertilizer(s) for good



Figure-26 Screening of vegetable germplasm at NTHRI, Shinkiari

growth and yield of tomato.

- Screening of 48 tomato lines for traits of economic importance.
- Introduced Broccoli crop for the first time in District Mansehra.
- Produced 0.40 million seedlings of different high value vegetables crops i.e., onion, cauliflower, cabbage, Chinese cabbage, broccoli, lettuce, tomato, chilies, brinjal and sweet pepper. Nursery was utilized for distribution among various stakeholders
- Produced seeds of OPVs i.e., onion, kale, radish, spinach, turnip, coriander, peas, cabbage, tomato, chilies. brinjal.
- Practiced offseason vegetable production in the walk in tunnels at NTHRI.



Figure-27 Broccoli introduction at Shinkiari

Medicinal Herbs

- Managed the Medicinal Herb Garden comprising of Cool mint, lavender mint, apple mint, asavi mint, camphor mint, piper mint, mentha peperita, menthe sp., local mint, achillea mellifolium, iculanchoe, thymus serpyllum, hypencum sp., banshfa, plectranthus varigata, plectranthus ambloricus, alovera, lavender, oregano, rosemary, Line seed, Flea seed, Thyme, Saffron (Pakistani & American) and Chamomile.
- Developed production technology of medicinal herbs and mushroom under local conditions



Figure-28 Collection of medicinal herbs at NTHRI, Shinkiari

OLIVE CULTIVATION

Research Highlights

- As a result of bursting campaign for olive promotion, the Government of Pakistan declared olive as a flag ship project and included olive in the vision 2025.
- Olive promotional project has completed Plantation of 144097 plants at 538 hectares during the year 2014-2015 in different districts of Punjab, Khyber Pakhtunkhwa, Baluchistan and FATA.
- Two methods, cuttings and air layering were practiced for propagation purpose. 20 % of these will be sapling after two years
- Conducted eight trainings on different aspects of olive in which 304 farmers have been benefitted.
- PARC technicians visited different olive farmer fields in Punjab, Khyber Pakhtunkhwa and Baluchistan and developed comprehensive field inspection reports.
- A survey was conducted to the farmers' fields of plain areas of southern Punjab (Mianwali, Bhakkar, Layyah, Multan, Bahawalpur, Rawalpindi, Attock) for recording of data regarding plant growth parameters.
- The olive growers were also guided for the plant protection measures and production technology.
- Farmers' fields of Punjab, Khyber Pakhtunkhwa, FATA and Baluchistan were visited regularly for feedback and guidance.
- Facilitation to the farmers for olive oil extraction was provided free of cost by the project.



Figure-29 A Plantation site



Figure-30 Olive soft wood cuttings at HRS, Nowshera

- Established 12 farmer associations in Punjab, Khyber Pakhtunkhwa, FATA and Baluchistan to play active role in olive plantation, its value addition and for development of market supply chain of olive and its byproducts.
- Project has updated the data of 500 olive orchards on GIS and uploaded the data at PARC web.
- The olive value addition experiments for pickle, jam and syrup with different combination of preservatives and recipes remained in progress.
- Experiments were also conducted on value addition of olive fruit for preparation of olive jam, biscuits, pickle in oil, sweets, olive beauty cream and some other makeup items at Punjab and Khyber Pakhtunkhwa.

FRUIT CROPS

Crop Improvement

- The High Density Planting (HDP) enables higher regular yield and improved farm management practices leading to higher productivity with better quality and profitability. Five exotic Olive cultivars (*Koronieki*, *Coratina*, *Chetoi*, *Arbequina* and *Magron*) were planted in HRI, NARC to select the cultivars suitable for high density plantation. The lower plant height (45.7cm), plant spread (10.1cm) and stem girth (1.48cm) was recorded in Arbequina followed by Karonieki with plant height (62.1cm), spread (11.02cm) and stem girth (1.49cm) whereas higher plant height (68.8cm) was recorded in Chetoi.
- Citrus exotic cultivars were planted in fruit area HRI, NARC for the evaluation study. The growth data was recorded to check the adoptability of these cultivars. The minimum plant height (67.64cm), plant spread (54.24cm) and stem girth (7.84cm) was observed in Arnold Blood followed by Cara Cara with plant height (86.86cm), spread (64.45cm) and stem girth (9.43cm) where as maximum plant height (150.2cm) and plant spread (99.98cm) was recorded in Torocco.

Popularization of New Fruit Crops

- The kiwi fruit (*Actinidia deliciosa*) is a perennial, deciduous, woody vine native to south China. Kiwi Plants (1000) of Hayward Variety were received from Nepal with collaboration of ICIMOD office (NARC). 500 plants were distributed to BARI, Chakwal and NTHRI, Shankiari, Mansehra for plantation.
- 500 Kiwi plants were shifted in pots (peat moss media) kept under control condition at HRI, NARC for testing the performance.



Figure-31 Cleft grafting technique in Kiwi plants (100 % success rate)



Figure-32 Kiwi plants under controlled condition

Establishment of High Density Demonstration Orchard

- High Density Demonstration block (16' x 12') was established at NARC for fruit growers. The plantation pattern consists of 437 Olive plants of 5 varieties (*Koroneiki*, *Coratina*, *Chetoi*, *Arbequina* and *Megaron*), 161 Almond plants of 4 varieties (*Karishma*, *Lajawab*, *Frost star*, *Non-Perial* and *Blank row*), 115 Pomegranate plants of 3 varieties (*Qandhari*, *Sultan* and *Tarnab Gulab*), and 990 Peach plants of 4 varieties (*Florida King*, *Early Grand*, *Spring Crust* and *Flame Crust*).



Figure-33 Field view of high density plantation block

Propagation

- An experiment was designed to identify the better propagation technique in avocado. Two avocado cultivars (*Fuerette*, *cyclone purple*) were propagated through cleft grafting and tongue grafting technique. Best results were obtained in cleft grafting (80% success) whereas in tongue success rate was 60%.
- An experiment was conducted in green house under mist to identify the rooting ability of Olive cultivars. Maximum rooting percentage (70.8 %) was observed in *Coratina* followed by *Picholine* (61.34 %) whereas lower rooting percentage was found in *Uslu* (34.4%) and *Nocellera del Belice* (22.22%).
- Following fruit plants were propagated through cuttings:
 - **Pomegranate:** 5300 Pomegranate cuttings were planted for propagation.
 - **Grapes:** 4850 Grapes cuttings were planted in nursery beds for propagation.
 - **Fig:** 7250 Fig cuttings were planted in nursery beds for propagation.
 - **Mexican Acid lime** 1000 true to type plants were propagated through cuttings.

- Nursery of following fruit crops was raised:
 - **Avocado** Germplasm (36 seeds from Tanzania) and 200 seeds of already evaluated varieties were sown in black plastic pots.
 - **Citrus rootstock** (Sour Orange): 4000 Seedlings were raised in open field.
 - **Peach rootstock** 2000 plants were raised and shifted in nursery beds.
 - **Loquat** 1750 seeds were sown in nursery bed.
 - **Falsa** 1500 plants were produced through seedlings.

VEGETABLE CROPS

Research Highlights

- The crossing block comprising of five chili lines was transplanted in isolation to protect from foreign pollen contamination and out crossing. the detail of the crossing scheme and number of successful cross combinations is as under

Cross combinations	No. of attempts	Successful combinations (%)
NARC-14/9 x NARC-16/5	600	60%
NARC-16/8 x NARC-14/9	600	45%
NARC-16/8 x NARC-16/9	550	60%
NARC-16/8 x NARC-16/4	600	60%
NARC-16/9 x NARC-15/6	380	60%



Figure-34 Indigenous hybrid development in Chillies at NARC

- The secondary evaluation performance of the 05 elite indigenously developed chili hybrids (Hybrid-1, Hybrid-2, Hybrid-3, Hybrid-4, and Hybrid-5) along with their 06 elite parents/inbred lines (NARC-15/6, NARC-16/9, NARC-16/4, NARC-16/8, NARC-16/5 & NARC-14/9), two commercial chili varieties (Lounghi and Tatapuri) and an international chili hybrid (HYB-222) was carried out at Vegetable Crops Research Programme, Horticultural Research Institute, NARC Islamabad. Locally developed chili Hybrid-5 out yielded (36.68 t/ha) the others.

Hybrid/parental lines	Green Fruit Yield (t/ha)
Hybrid-5	36.68
Hybrid-1	36.17
NARC-16/8	35.64
NARC-15/6	33.65
Hybrid-4	31.15
Hybrid-2	28.68
NARC-16/4	28.63
222-Hybrid	28.42
NARC-16/9	27.97
Hybrid-3	27.94
NARC-14/9	25.95
NARC-16/5	25.22
Tatapuri	16.0
Lounghi	4.6



Figure-35 Indigenously developed chillies hybrid-5 performance at NARC

- Eight stable **bitter** gourd inbred lines (I.B.L 01, I.B.L 02, I.B.L 03, I.B.L 04, I.B.L 05, I.B.L 06, I.B.L 07 & I.B.L 08) and five OPVs (Faisalabad Long, Kala Karela, Vehari Small, Vehari Long & Vehari Medium) were maintained through manual sib-matings. Self pollination was followed in the bitter gourd material for the progression of material towards the development of stable inbred lines.



Figure-36 Inbred line development

- Plastic mulched crop of bitter gourd was not only matured earlier by 10 days over the control (non-mulched crop) but also increased the yield by 40 per cent.
- Nine elite homogeneous field **tomato** parental lines were maintained in the field. The true to type plants in all of the parental lines were retained by rouging out of the off type plants. The pure seed of these parents were being used for hybrid development. The crossing block was established by making use of six lines viz., Riogrande, Roma, VCT-1, Pakit, Peto-86 and Nagina along with three tester viz., BSX-935, 17905 and Continental. The crossing was made following line \times tester fashion. Each line was crossed to each of the testers thus, making a total of 18 cross combinations.



Figure-37 Tomato field

- Fruit setting was reduced in **tomato** exposed to high temperatures. Two growth regulators (4-chloro-phenoxyacetic acid (4-CPA) and Naphthalene acetic acid (NAA) increased fruit set and fruit yield per plant as compared to control under high temperature.
- The evaluation of **Garlic** genotypes for yield and yield components was conducted. Maximum bulb weight (118.04 gm) was recorded in "NARC-G-01", followed by "BG-1" and "Italian" with 83.07 and 80.0 gm bulb weight respectively. Maximum fresh bulb yield (24.93 t/ha) was recorded in cultivar "NARC-G-01", followed by cultivar "Italian" and "BG-1" with 21.06 and 20.40

t/ha respectively . The minimum fresh bulb yield (14.33 t/ha) was noted in cultivar "Lehson gulabi (check)."

- Yield potential of onion strains (TG-502 & TA-377) were investigated under different planting dates and planting geometry. Maximum bulb weight per plot was achieved by planting on November 15. TG-502 gave significantly higher yield as compared to TA-377 & Phulkara (check). Maximum bulb weight per plot was achieved in plant spacing of 6 cm.
- Response of onion variety (Nasarpuri) to different levels of farmyard manure and nitrogen was investigated at SARC, Karachi. The seedlings of onion variety Nasarpuri were transplanted on already well-prepared ridges on 16-12-2014, the row to row and plant to plant distance were kept 60 cm and 20 cm respectively. The data revealed that the application of nitrogen @ 60 kg/ha produces longest leaf length i.e. 42.3 cm as compared to control that produced only 31.36 cm leaf length, whereas the value for all the remaining treatments varies from 31.36 cm to 40.6 cm. The addition of farmyard manure @ 10 ton/ha produces maximum number of leaves/plant (10.8), in contrast under control the number of leaf/plant remains only 7. Maximum bulbs diameter (16.66 cm) were observed with the addition of farmyard manure @ 10 ton/ha, whereas the values for rest of treatments ranges between 12 cm to 15.84 cm. Maximum leaf diameter (6.2 cm) were observed in plants when treated with nitrogen @ 45 kg/ha. The value for rest of the treatments varies from 3.12 cm to 5.52 cm.

POTATO

Research Highlights

- Four new clones developed at NARC [Viz; *NARC 2002-1, 393574-72, 2005-1 and NARC 2005-4*] yielded more than 30 tones/ha at farmer field as well as at NARC when compared with standard variety Cardinal (24.0 t/ha.). The potato seed of above mentioned clones have been increased for further evaluation in NUYT and other experiments.
- Six crosses from potato breeding germplasm (Chipsona X NARC-22, 9619X SH-5, Horizon X TPS-13, FD 1-10X SH-5, Horizon X Sarpo Mira) were selected and seed of these crosses were multiplied to be used for further evaluation.
- 17 exotic potato varieties (*AGB Red, Rose Mara, HZD 02-1499, HZD 03-941, HZD 04-684, Compass, Flamba, Stemster, Metro, Saturna, Zina Red, Safari, Amarin, Triplo, Melanto, Dirosso and Lombardo*) were evaluated in Adaptability Testing Trial during spring 2014. According to results the highest yield 42.39 t/ha was recorded in variety Zina Red followed by Rose Mara and Compass 35.06 and 33.28 t/ha respectively. All the varieties except Dirosso showed yield more than 20 t/ha and found better in yield. All these varieties have potential to get popularity among potato growers.
- 15 Potato varieties/clones were evaluated to calculate dry matter percentages. Asterix, Tripplo and Zena Red showed better keeping quality and high dry matter with attractive shape and color. These quality traits of these clones/varieties made them suitable for making the French fries or crisp. The quality attributes were recorded as follows:



Figure-38 Field evaluation of potato germplasm

Groups	Specific Gravity	Dry Matter (%)	Varieties Evaluated
Very low dry matter (table potato consumption)	< 1.060	< 16.02	
Low dry matter (table potato consumption)	1.060 1.069	16.2 - 18.1	Melanto, Flamba, Stemster,
Medium (French fries)	1.070 1.079	18.2 - 20.2	Compass, HZD-1499, Lombardo, HZD-684, Saturna, AGB-Red, Amerin,
High (Crisp)	1.080 1.089	20.3 - 22.3	Zena Red, Tripplo, Asterix, Cardinal

- Performance evaluation of 21 exotic potato varieties was done at CDRI Karachi. Among insect/pest, aphid attack was observed on all the varieties but it was below the economic threshold level; therefore no insecticides were applied. The variety Loane was found affected by late blight. The performance of these varieties is as below:

Varieties	Plant height (cm)	No. of shoots/plant	Tuber length (cm)	Tuber circumference (cm)	Tuber wt. (gm)	Total tuber wt./ plant (gm)	No. of tubers/plant
Focus	45	3	8.76	14.9	86.59	162.25	3.2
Miss Mignne	29.4	2.4	8.26	12.68	65.75	367.95	6.6
No. 291	21.4	2	7.76	14.08	66.90	189.3	4.2
Miss Andes	22	2.2	7.52	12.24	60.02	252.20	6.2
Ronaldo	25.6	1.6	10.12	15.16	115.95	388.54	5.2
Sagitta	43.6	3.2	6.06	14.08	73.28	243.52	4.2
Bartina	65.2	3.8	8.5	14.46	62.32	258.68	5
Asterix	88	4.8	9.98	13.4	114.92	364.62	7.6
Roko	56.2	3.8	6.02	13.38	58.4	146.28	3.2
Cimega	37	2.4	10.42	15.04	115.93	280.71	3.6
Loane	32.6	2	7.82	13.98	23.18	202.87	4
Sante	24.4	1.6	5.48	12.48	53.70	169.67	4.2
Sapro Mira	28.4	1.6	5.42	11.72	57.67	188.81	4.4
Romeo	24.4	1.6	6.6	12.12	52.57	154.92	5.4
Rudolph	33	2.6	7	13.44	54.86	134.51	3.2
Challenger	25.4	1.6	6.98	11.98	39.47	129.42	3.8
Diroso	29.8	2	8.04	14.04	77.42	140.25	3
Kastelli	50.2	2.6	8.24	23.1	82.68	189.56	4
Triplio	51	3.2	7.6	14.72	85.04	208.726	4.6
Amarin	54.4	4.4	7.92	14.52	98.48	303.83	6
Mel Anto	71.4	5	7.88	15.32	138.48	298.73	8.4

- A training on “Seed Potato Production Technologies” was organized by the Potato Program, NARC. 23 participants belonging to various stakeholders were familiarized with the latest production technologies, modern crop management practices and cultivation of their own seed potato to reduce their dependency on high-cost imported seeds.
- Hands-on Training was imparted in Seed Potato Crop Management Capacity Building of Farmer’s Enterprise Groups in Gilgit Baltistan. 1125 farmers were trained at five locations (Jhalkand, Batakundi, Darel, Batoga and Yasin valley) in three districts (Mansehra, Diamer and Gizer).

CROP DISEASES

Identification of sources of resistance in wheat

- In *National Wheat Diseases Screening Nursery* 480 wheat lines were planted to screen against the Leaf rust (Lr) at 9 locations, Yellow rust (Yr) at 3 locations and Stem rust (Sr) with local race RRTTF at Crop Diseases Research Institute (CDRI), Karachi. There were 39 lines found resistant to all the three rusts with Average Coefficient Infections below 9. Two hundred and one advance lines were found resistant to leaf and yellow rusts while 22 lines to leaf and stem rusts. Similarly 17 lines were found resistant to yellow and stem rusts.
- Among forty candidate lines under *National Uniform Wheat Yield Trial*, twenty eight wheat lines gave desirable Relative Resistant Index (RRI) for leaf and yellow rusts. There were only four wheat lines which have coefficient infection less than 9 against local stem rust race RRTTF. 16 lines were found Moderately Resistant to Moderately Susceptible and severity was more than 40%. Five lines were found Moderately Susceptible to Susceptible.
- Among commercial wheat varieties, the dominant wheat varieties Faisalabad-08 and Seher-06 were found susceptible to Lr and Sr while the newly released wheat variety Galaxy-13 was found susceptible to all the three rusts. Most of the varieties were found ineffective at CDRI Karachi against stem rust race RRTTF. Benazir-2013, Chakwal-50, BARS-09, Aas-11, NIFA Lilma, NIA-Sarang, Pakistan-13, Pirsbak-13, Siren, and Shakar-13 provided resistant to three rusts.



Figure-39 Recording of field observations at RARI, bahawalpur (up) and AARI, faisalabad (below)



- Among the exotic germplasm, the *1st Regional Bread Wheat Key Location Disease Nursery* (595 lines from ICARDA) and *Regional Durum Key Location Disease Nursery 2015* (461 lines) were evaluated. Diseases data observation against Yr recorded at NARC, Islamabad revealed that 568 lines of *1st Regional Bread Wheat Key Location Disease Nursery* were resistant to the prevailing races of stripe rust. All the lines of *Regional Durum Key Location Disease Nursery 2015* were found resistant to stripe rust but heavily infested by foliar blight.
- *10th International Stem Rust Trap Nursery* was planted at 10 locations of Pakistan. Maximum rusts severities were recorded at CDRI, Karachi. This is due to the nearby inoculation with local race RRTTF. The stem rust resistance genes Sr31 were found effective that indicates the absence of UG-99 in Pakistan.
- *8th And 9th Yellow Rust Trap Nurseries* were planted at 15 locations of Pakistan. The data revealed that there was no virulence on yellow rust resistant gene Yr5, Yr10, Yr15 and YrSp, hence are recommended for incorporation in breeding programmes.
- *5th and 6th Leaf Rust Trap Nursery* was planted at 14 locations of the country. No virulence was observed on leaf rusts resistant genes Lr9, Lr19, Lr10, 27+31 (Gatcher) and Lr28 which are being recommended for incorporation in breeding programmes.
- Comprehensive survey was conducted in the AJK districts Bhimber, Mirpur, Kotli, Rawlakot, Muzaffarabad, Bagh, Hattian Bala and Neelam valley. Leaf rust prevalence was 36% and the incidence was in the range of 1-30%. While the prevalence of yellow rust was 30% and the incidence was in the range of 1-20%. No stem rust was observed in any field of AJK. Samples were collected for virulence analysis.



Figure-40 Leaf rust at AZRI Bhakkar



Figure-41 Stripe rust at Fatehjang

- Wheat advance lines in NWDSN & NUWYT and commercial varieties were evaluated against Powdery Mildew at Agricultural Research Station, Mansehra. Among the genotypes, 44 lines were found highly susceptible, 188 susceptible, 118 moderately susceptible, 33 moderately resistant, 45 resistant and 15 highly resistant.



Figure-42 Yellow rust at gadhi dopatta (Muzafferabad)

- To determine the resistance level against Spot Blotch of wheat, a field screening by artificial inoculation of 40 NUWYT, 480 NWDSN and 122 commercial wheat varieties was conducted against *Bipolaris sorokiniana* at NARC, Islamabad. Out of 40 NUWYT entries only one entry showed resistance, 11 MR, 21 MS and 4 showed S reactions. Out of 480 NWDSN entries, only five entries exhibited R, 141 MR, 170 MS, 85 S. Out of 122 commercial varieties none of the variety showed R type reaction, 14 varieties showed moderate resistance (MR), 42 varieties showed moderate susceptibility (MS), 35 varieties showed susceptibility (S), while 26 varieties showed high susceptibility (HS). The resistant sources are strongly recommended to be used in breeding programs.



Figure-43 Powdery mildew data recording at ARS, Baffa, mansehra

Rust Surveillance

- CDRI-SARC, Karachi conducted extensive surveys of wheat crop under WPEP Project Objective-1 Surveillance activities to monitor the prevalence and distribution of wheat rusts in different agro-ecological zones of Sindh. The maximum infection of leaf rust were recorded at the localities of District Thatta on Khirman 80 to 90S with 80% incidence, Matiari, Kiran-95 80S with 60% incidence, Sehar-06 90S with 90% incidence at Obaro, Galaxy-13 70 to 80S with 80% incidence at Sangi, TJ-83 60MSS with 20% incidence at Kunri, etc. The maximum infection of yellow rust were recorded on Kiran-95 80S with 80% incidence at Daulatpur, TJ-83 Cross line V5 80S with 80% incidence at

Ghotki, TJ-83 60S with 40% incidence, TD-1 60MSS with 50 to 60% incidence, Sarsabz 20S, NIA Ambar 20S, NIA Sunheri 20MSS, NIA Sundar 10MSS, Wattan-94 60S, etc. The prevalence of stem rust was recorded only at two locations. The maximum infection of stem rust were recorded at Allah Tawakkal farm Umerkot on Galaxy-13 i.e. 60MS with 20 to 30% incidence.



Figure-44 Rust surveillance activities in Sindh

Screening of sunflower material against different diseases under field conditions

- Sixteen entries of National Uniform Sunflower Yield Trials (NUSYT) were evaluated for Phoma blight, Alternaria leaf spot, charcoal rot and bacterial head rot. Due to the frequent rains and relatively cool weather in the current season the charcoal rot severity was very low. Similarly the other two leaf diseases like Phoma and Alternaria blight was also in traces. The bacterial head rot disease (*which was reported for the first time from Pakistan during last year*) has been observed prominently in mild to severe form on various entries. Among sixteen entries one hybrid exhibited MR reaction while rest were resistant (R) against Phoma disease, whereas all the tested hybrids showed R reaction against Alternaria leaf spot. Three entries exhibited MR and MS reaction against charcoal rot. The maximum bacterial head rot was recorded on two hybrids exhibiting highly susceptible reaction.
- In another set, eighteen hybrids (*both local and exotic*) were evaluated against these diseases. All the hybrids showed R reaction against Alternaria leaf spot while one hybrid showed MR and MS reaction each against Phoma blight whereas all the rest showed R reaction. In case of Charcoal rot 12 hybrids showed R reaction, three MR, two MS and one hybrid showed S reaction. In case of bacterial head rot nine hybrids showed high resistance (HR) four were R, three were MR, and one hybrid each exhibited MS and HS reaction. Charcoal rot was observed on all the entries but only one entry each exhibited MR and MS reaction while the rest showed R reaction. Bacterial head rot was also prominent on local hybrids and five showed HR, three showed R, seven MR, two hybrids showed S and only one hybrid showed HS reactions.

Banana Diseases

- Two surveys were conducted in banana growing areas of Tando Jam, Naserpur, Matiari, Sukrand, Shaheed Benazirabad, Khairpur, Thatta and Karachi. There was no evidence of the **Panama Wilt** disease in any of the orchards observed in Tando Jam, Naserpur, Matiari, Sukrand, Khairpur and Benazirabad. However the disease was prevalent in most of the orchards of Thatta. However it was observed that the growers in Thatta have replaced the old plantations and in many orchards the plantation along with soils were washed away by the flood which resulted in incidence of low frequency ranging from 5 to 13.5%. In addition to the foc isolates a total of 5 parasitic nematodes species including *Radopholous spp*, *Helicotylenchus spp*, *Tylenchorynchus spp*, *Xiphinemaspp* and *Longodorousspp* has been isolated. Altogether on the basis of two surveys conducted to ascertain the distribution of Panama wilt it is evident that the disease is prevalent in most of the fields of Thatta districts and it's still restricted in these areas. There is a need to observe the strict quarantine measures for the movement of the sucker from Thatta district to other parts of the banana growing areas of the Sindh province to avoid its dissemination to the areas free of this disease.
- During a survey of tissue culture plantations at 13 locations, 2221 number of leaf samples tested by DAS-ELISA for **Banana Bunchy Top Virus (BBTV)**. Out of these, 437 were found infected with BBTV i.e 32.13%. This infection indicates the need to apply the methods of control, viz. early identification, and eradication of infected plants and the use of virus-free planting material. During the second survey, 132 samples were collected and tested. In addition to BBTV another virus namely **Banana Bract Mosaic Virus (BBrMV)** was also identified on the basis of symptoms and DAS ELISA.

Screening against potato Viruses

- A total of 1500 random foliar samples collection for DAS-ELISA was carried out from Dipalpur and Kasur districts. Out of them 1000 samples were tested for Potato Virus X (PVX), Potato Virus Y (PVY) and Potato Leaf Roll Virus (PLRV). The individual percentage infection of PVX, PVY and PLRV was 17.80, 20.9 and 17.700 % respectively. The overall mixed infection was 16.6%. The 500 samples were tested against six economically important viruses, namely Potato Virus A (PVA), Potato Virus Y (PVY), Potato Virus X (PVX), Potato Virus S (PVS) and Potato Virus M (PVM), Potato Leaf Roll Virus (PLRV), and the percentage infection was 9.7, 11.2, 9.5, 0, 10.5 and 7.6 percent respectively.
- A total of 7500 Acre fields were surveyed in the four districts of Punjab belonging to 7 potato growing areas i.e. Qasur, Chunia, Depalpur, Okara, Sahiwal, Chichawatni and Chinot. Out of 150 fields sampled from these seven

tehsils only Chunia was found completely free of Potato Cyst Nematode (PCN). In other surveyed fields the incidence was ranged from 16 to 24%, however it was observed that all the cysts that were recovered from these soils were old and no new cyst was found.

Management of Onion Wilt

- An experiment was conducted at SARC, Karachi to find out the effect of oilcakes as soil amendment and drenching on basal rot and foliar diseases and yield of onion. Data on incidence of basal and foliar rot diseases were recorded during the crop season. Onion wilt and basal rot caused by *Fusarium oxysporum* was noted 10% in non-treated and 2% in treated trial. Foliar blight spot were noticed in all treated and non-treated trials. No significant difference in yield was noted in treated and non-treated trial.

ECOTOXICOLOGY

Research Highlights

- A study was conducted to investigate the efficiency of aquatic macrophyte i.e. *Nasturtium officinale* for the removal of cadmium from waste water and its potential in phytoremediation technology. Metal uptake by the plant was dependent upon the concentration of the metal and the duration of exposure. Metal content in plants increased with the increase in metal concentrations in solution and the accumulation in shoots was significantly higher than that in roots. Chlorophyll contents decreased with higher levels of Cd exposure. Moreover, the values of bio-concentration factors as well as the values of translocation factors for Cd removal were greater than one which indicated that the *Nasturtium officinale* is an ideal candidate for phytoremediation of cadmium.

- For the analysis of Polyphenolic compounds, and antioxidants, in peels of Apple, Citrus, Grapes, Carrot and Pomegranate, two methods for analysis on HPLC using reversed phase chromatography were developed; one on $\lambda = 280\text{nm}$ & $\lambda = 370\text{nm}$. Fifty samples of Grapes, Carrot and Pomegranate were analyzed for 14 Polyphenolic antioxidant compounds on HPLC at these wavelengths. Moreover, 60 samples extracted from Mango, Apple, Citrus peel were also analyzed for 13 poly-phenologic compounds (antioxidant) on HPLC with UV detector using C18 column.



Figure- 45 Visit of Ecotoxicology Research lab at NARC

- Collected samples from Volta Battery from industrial estate Hattar for monitoring baseline of heavy metal contamination.
- Analyzed water samples collected from I-9/I-10 industrial state. The level of Fecal/Total Coli forms turbidity, Total Dissolved solids and Total suspended salts were found beyond National Environment Quality Standards.
- A project titled "National Pesticide Residue Monitoring System of Pakistan" was developed and being implemented with the objectives to establish/strengthen a well-coordinated network of pesticide residue

analysis/testing laboratories and development of Centre of Excellence in Pesticide Residues; accreditate the Labs as per ISO 17025; help promote food quality and safety both from public health and trade perspective; develop core man resource in this specialized area of pesticide research/analysis.



Figure-46 *Participants of a workshop on pesticide residue monitoring system*

INSECT PEST MANAGEMENT

Integrated management strategies for fruit flies

- Fruit flies management strategies incorporating the Male Annihilation Technique (MAT), Bait Application Technique (BAT) and field sanitation were demonstrated in cluster farms selected by Department of Plant Protection (DPP) of mango (10 clusters in Multan area), and citrus (10 clusters in Sargodha region). Ten service providers were trained in citrus and mango growing areas for management of fruit flies.



Figure-47 Field demonstrations of fruit fly management strategies

- These strategies were also demonstrated in guava (8 clusters in Sharqpur and Kohat region) and bitter gourd (4 clusters in Charsadda region). Additionally, fruit fly MAT was demonstrated in ICT urban area. Extensive survey and mass trapping of fruit flies showed that the prevalent species in mango and citrus growing areas are *Bactrocera dorsalis* and *Bactrocera zonata* while fruit flies trapped from bitter gourd fields was *Bactrocera cucurbitae*. Pure methyl eugenol (ME) (>95%) had more attraction to males than ME commercially available in Pakistan (25%). Fruit flies population remained high during the whole year with least number of males trapped during January to March. These initial results showed that fruit flies management measures should be practiced round the year but on area-wide basis.

Biological control

- Explored the predatory potential of *Chrysoperla carnea* against lepidopteran caterpillars (*Helicoverpa armigera*, *Chilo partellus*, *Spodoptera litura*) and sucking insect pests (aphid species *Schizaphus graminum* and *Myzus persicae*) under controlled conditions.



Figure-48 Studies on biological control

- Predatory potential of *Harmonia dimidiata* against two aphid species *Schizaphus graminum* and *Myzus persicae* aphid under free choice and no choice methods.
- Host *Sitotroga cerealella* and parasitoid *Trichogramma chilonis* density response studies showed that *Trichogramma chilonis* parasitism rate was maximum (82%) at 1:5 (20 *T. chilonis* per 100 *S. cerealella* eggs). Parasitoid density variable studies showed that parasitism at 12 *T. chilonis* adults per 50 eggs of *S. cerealella* was the highest (75.2%).

Host plant resistance

- Seventeen **sugarcane** genotypes were evaluated against borer infestation. Maximum infestation was observed in genotype HOSG-31 (11.8%) followed by NARC-1 (8.4%) and BPTH-804 (6.2%) whereas the genotypes AUS-384 and YT-53 showed no borer infestation.
- Sugarcane genotypes (17) were evaluated against termite infestation. Maximum infestation was observed in genotype YT-55 (10.6%) followed by 804(9.4%) and SPSG-24 (8.5%) whereas the genotypes NARC-02, CPSG-2875 and AUS-384 were free from any termite damage.
- Evaluated 14 fine rice genotypes against rice borer infestation. Highest borer infestation was observed in genotype FR-5 (7.4%) and FR-8 (4.0%) whereas genotypes FR-2, FR-6, FR-7, FR-9, FR-13 and FR-14 were immune to borer infestation. 7 coarse rice genotypes were also evaluated against rice borer. Highest borer infestation was observed in genotype CR-3 (6.7%) and CR-2 (4.4%) whereas genotypes CR-5, CR-6, CR-7, CR-8 and CR-9 had no borer infestation.

INTEGRATED PEST MANAGEMENT

Management of CLCuV disease

Under ICARDA-USDA CLCuV project, the following are the key outputs:

- Creation and improvement in knowledge and awareness as well as capacity building of 6759 small cotton farmers and 54 agriculture extension personnel, community activists and facilitators of ten cotton growing districts of Sindh (Khairpur, Nawabshah, Sanghar & Umerkot) and Punjab provinces (Bahawalpur, Bahawalnagar, DG Khan, Khanewal, Multan, and Vehari) regarding integrated management of CLCuV through establishing 155 Farmer Field School (FFS) and 112 Participatory Learning Groups (PLGs).



Figure-49 FFS Facilitators in Refresher Training

- The major and successful CLCuV management practice was the use of macro and micronutrients (foliar application) for the recovery of cotton crop from CLCuV disease. Early sowing and resistant varieties also gave good production with less incidence of the viral disease.
- A guideline entitled "Cotton Best Management Practices" was developed for farming community and stakeholders. One FFS Data Record Keeping Book was also developed.



Figure-50 Farmers in FFS session

Mango Value Chain Enhancement

- The continuous awareness on the needs of **High Health Nurseries** among growers, the Australia-Pakistan Agriculture Sector Linkages Program (ASLP) -

Mango component has been able to convince and add 04 more commercial nurseries in Pakistan. Now the existing high health nurseries are 12 including 06 commercial and 06 research nurseries. During 2014-15 the nurseries have sold about 150,000 plants. An effort is being done to present high health nurseries as family business at household level without compromising on the basic principles and standards.



Figure-51 High health nursery at Rahimyar Khan

- For improved Mango Orchard Management, the macro infusion injection was introduced to growers of Punjab and Sindh for quick remedy of mango sudden death affected trees. Due to increasing demand, its being multiplied for its commercialization.
- This year more than 450 growers, 50 researchers, 200 extension workers were trained on various aspects of modern mango husbandry which resulted in good mango crop and a boost in export.



Figure-52 Demonstration of macro infusion injection

- Bioassays were conducted at SARC, Karachi to compare the effect of neem oil, diatomaceous earth (DE) and clay against *Tribolium castaneum* (Coleoptera: Tenebrionidae). All insecticides were tested at five dose rates. After 15 days neem oil showed 100% mortality, even at low dose while diatomaceous earth showed 100% mortality at higher doses (1250 and 1500 ppm). In case of clay mortality did not reach to 100%, even at higher dose.

BIOREMEDIATION

Research Highlights

- This simple, applicable and cost effective technology was used to reclaim used water. The output of this activity will provide the pool of water fit for irrigation as per NEQ's. The salient accomplishments are as below:
- Establishment of Model Bioremediation Facility at Rose and Jasmine Garden Islamabad with RADP funding. The facility was established with the cost of Rs 6.75 million in collaboration with CDA. The activities conducted comprised of introduction of aquatic plants, plantations of fruit plants, Introduction of Microbial Consortia, Construction of Detention Ponds, and Hydropower Generation.
- Demonstration of Innovative Practices to Improve Rural Livelihood Through Integrated Farming Resources Management under Watershed conditions of Potohar Region at village Kamrial, Distt. Attock.
- A OIC-COMCEC funded project entitled "Pakistan Bioremediation Model for Wastewater Treatment and Capacity Building Program among OIC Countries" was successfully concluded. The major activities of the project included; coordination with identified partner countries' stakeholders for developing common understanding of the project concept, four official study exchange visits to enhance researchers' capacities and to monitor ongoing capacity building activities and adoptability of the concept, arranging a workshop for all partner countries' project focal persons at Islamabad Pakistan for capacity building of the hybrid concept of



Bioremediation for treating wastewater for irrigation, developing joint website for all partner countries for sharing, learning and improving the concept and technology for future continuation, visibility of the COMCEC project coordination activity on national & international electronic/print media, publication of the report and sharing results with the COMCEC member countries.



Figure-53 *Bioremediation facility at Rose & Jasmine Garden, Islamabad*

NATIONAL INSECT MUSEUM

Research Highlights

- Thirteen surveys were conducted for the collection of insects (pest, predator and pollinator) of different agro-ecosystems from Bhambala, Kohata, Bhimber, Bhara Kahu, Simly Dam, Angoori, Keintla, Murree, Kala Bagh, Kohala, Alioute, Mangla, and Lethrar.
- Neuropterids are important agricultural predators. With the addition of 03 genera and 03 species record for total identified species has become 06 under 11 families and 16 genera.
- Members of order Odonata are popular agricultural predators and water pollution indicators. Up till now 12 species of naiads under 04 families and 15 species of adults including one new to science species (*Calicnemia fortis*) has been identified and added to national collection. The Holotype of this species is kept at National Insect Museum while Paratype is deposited in Insect Museum at Germany.
- Insect Pollinators of **Apple** and **Mango** were investigated at Murree (25 sites) and Multan (35 sites). Collected specimens were identified into 23 species under two orders (Hymenoptera, Diptera). *Musca* sp. (Family Calliphoridae) followed by *Episyrphus balteatus* (Family Syrphidae) emerged to be the



Figure-54 Collection of insect pests in field



Figure-55 Aquatic insect fauna collection



Figure-56 *Calicnemia fortis* sp. Nov. (New to science record of Odonata from Pakistan)

most prevalent insects with 43% and 23% relative abundance. At Murree specimens were identified as 29 species under three orders. i.e Diptera, Hymenoptera and Neuroptera. *Lucilia* sp. (Family Calliphoridae) followed by *Musca* sp. (Family Muscidae) emerged to be the most prevalent insect with 27% and 24% relative abundance respectively.

- Family Syrphidae comprises of insects that are predators, scavengers and pollinators in their behavior. More than 50 species have been identified up till now. *Merodon* sp., *Eumerus sexvittatus*, *E. nepalensis*, *E. albifrons*, *Volucella signata*, *V. ruficada*, *Helophilus quadrivittatus* are new records for the country.
- 8 species under 5 genera of 2 subfamilies have been identified in a study on Weevil fauna of Pakistan (Curculionidae: Coleoptera) housed at National Insect Museum. Among these, one genus is new record for Pakistan.

VERTEBRATE PEST MANAGEMENT

Research Highlights

- Screening of four bait additives/ attractants namely (peanut butter milk powder, egg shell powder & fish meal) in 2% proportions was carried out in multi-choice feeding tests in wheat crop by adding in top ranked bait base millet identified in the earlier experiments. Results of all the ten replications on the basis of average daily intake (ADI) indicated that peanut butter was maximum consumed (95.60)g followed by milk powder (82.44)g, egg shell (33.51)g & fish meal (20.55)g. On the basis of these results, we can say that addition of 2% peanut butter in millet has made the texture of bait base more attractive and palatable for final poison bait formulation.



Figure-57 Multi-choice feed preference tests of additives

- For Rodent and wild boar management at NARC campus, a total of 13513 burrows were treated in three treatments covering a total area of 666 acres by using fumigants followed by acute and chronic poisons in different crops. Overall 90% reduction in burrow activity was achieved in high value breeding/ experimental material. Moreover, a total of 109 environmentally safe PVC bait stations containing racumin grain bait were installed at 15 locations including Offices, Labs, Stores, Residential Colonies etc. Each bait station contained 100g of bait initially. Bait was replenished on weekly basis where required. No further damage reported from the area treated.



Figure-58 PARC Rat Kill

- Zinc phosphide (2%) grain bait has been developed in the form of "PARC Rat Kill" after performing series of field trails. The product is now commercialized.

- In a study comprised of laboratory evaluation of some vegetable oils as taste enhancers against Norway rat, *Rattus norvegicus* at SARC, Karachi, it was concluded, that vegetable oils when mixed with poison bait has potential to enhance the acceptance of offered bait, thus to achieve the desired success against rodent menace both in urban and field conditions.
- Varied occurrence of rodent contamination/filth in pulses sampled from main grain markets of Karachi was observed. The data is summarized as follows:

Markets surveyed	Rodent filth (gms) in major cereal commodities /250gms sample			
	Chana	Mash	Mung	Masoor
Saddar (Empress market)	1.18		1.10	0.64
Liaqatabad (Super market)	2.10	0.89	1.34	1.40
Nazimabad (Gole market)	2.25	1.82	1.11	0.89
North Nazimabad (Hyderi market)	1.09	1.2	0.96	0.76
Buffer zone (Shadman market)	0.99	0.87	1.01	0.56
New Karachi	1.26	0.86	0.97	0.56
Orangi town (Aligarh Market)	2.34	0.56	1.56	1.23
Water pump	2.50	1.89	1.89	2.70
Gulshan-e-Iqbal	1.20	0.86	0.87	0.45
Gulistan-e-Jauhar	0.98	0.65	0.77	0.67
Safora Goth	2.93	1.23	0.86	0.98
Quaidabad	1.23	1.67	0.66	1.32
Machi miani	2.10	1.45	1.08	1.92
Ranchore line	2.40	1.56	2.15	1.23
Jodia bazaar	1.92	0.98	0.65	1.29
Ramsawami	2.03	1.68	1.29	0.96
Khazoor bazaar (Lee Market)	1.95	1.05	1.43	1.21
Delhi colony	1.98	1.05	0.87	0.93
Neelum colony	0.97	0.86	0.83	0.69
Defence garden market	0.27	1.46	0.84	0.1

FLORICULTURE

Research Highlights

- Pure line selection of different varieties of Chrysanthemum and their mother block were prepared.
- Following ornamental/flowering plants were propagated and commercialized through PATCO.
 - 1500 cuttings of Chrysanthemum.
 - 200 cuttings of Coleus.
 - Different varieties of Amaryllis, Tuberose and Day-lily.
 - Gladiolus and Iris cut flower spikes.
- Five Urdu Brochures of different Ornamental plants/Cut flowers were printed namely; Rose, Chrysanthemum, Gladiolus, Iris, Coleus, Iris.
- Four brochures for Liliun, Gerbera, Summer Annuals and Winter annuals are being finalized.
- A bulb of flowering crops and their production technology was provided to Farmers and visitors.
- Lectures related floricultural crop production were delivered at Agricultural Poly-technique Institute (API) to trainees of different long/short term courses e.g. Production of cut flowers in Pakistan to farmers of southern Punjab.
- Recorded video on Flower production technology titled ' *Pholon ki kasht* '

PLANT INTRODUCTION

Introduction and Propagation:

- A total of 519 seedlings of **Bread fruit** (*Artocarpus altilis*) were received. Approximately 300 plants of the Bread Fruit are growing well in shed. The average plant height was 4.2 cm, No. of leaves 16, length of leaves 45 cm and No. of branches 2 was recorded. All healthy plants are being distributed to the growers in coastal area of Pakistan.
- **Roselle Herbal Tea** (*Hibiscus sabdariffa* L.) accessions were evaluated at SARC, Karachi. The number of leaves varied between 12 and 18 while average length of plants was recorded between 18 and 35 cm. PGRI-NARC Accession No. 02-04 and 07-09 performed well for growth and floral development as compared to remaining accessions. Calyx and Seed collections are in progressive.
- Eleven **Olive** (*Olea europaea*) plants of Arbosena and 04 plants of Arbequina varieties are growing well under coconut plantation. The average plant height observed was 108 and 137 cm, and no. of branches 14 and 28 of Arbequina and Arbosena respectively.
- Coconut (*Cocos nucifera* L.) is grown in coastal areas of two provinces, Sindh and Balochistan. The coconut mite is a very serious and devastating disease of the coconut. The tiny microscopic mites damage, distort and reduce size of the fruits. The fruits eventually turn brown and



Figure-59 Glimpses of studies at Institute of Plant Introduction at SARC Karachi

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- Coconut (*Cocos nucifera* L.) is grown in coastal areas of two provinces, Sindh and Balochistan. The coconut mite is a very serious and devastating disease of the coconut. The tiny microscopic mites damage, distort and reduce size of the fruits. The fruits eventually turn brown and finally drop. Incidence of coconut mite has spread to most coconut production areas and it has been considered one of the most notorious and important pests of coconut fruits in Coastal area. It was observed that essential oils (Neem oil + Castor oil) and their constituents have varying degree of pest controlling activities. The study indicated the possibilities of the use of botanical biocides as potential pest management strategies. The results of neem seed powder 200g + equal solution of Sand on Leaf axil filling at 45 days interval were also effective.
- To introduce cashew nut trees in Karachi, a trial was conducted in the month of March, 2015. Only one seed has germinated in the flower pot and plant is growing.

FOOD QUALITY & SAFETY

Monitoring of Resistance against Contact Insecticides

- Strain of *Sitophilus oryzae* collected from SGG-I Landhi was very highly resistant with resistant factor 17.105 folds.
- Strain of *Rhyzopertha dominica* collected from Trading Corporation of Pakistan, Bin Qasim was very highly resistant with resistant factor 9.67 folds.
- Strain of *Tribolium castanum* collected from SGG Landhi was very highly resistance with the resistant factor 8.68 folds.
- Effect of storage structures and period on wheat grain was investigated at farm level in Sindh. The results showed that grain temperature, grain moisture, weight of 1000-grain, insect infestation, seed germination capacity in different types of storage structures showed significant differences. The comparison of storage structures indicated that on average, weight of 1000-grain, seed germination capacity was significantly higher in grain samples taken from the puccki Kothies and metal bin than in pallies/straw bin and kacchi Kothies. Farmers should store their wheat in Metal bin and in the concrete block pucchi kothiest than the pallies /straw bin and kacchi Kothies.



Figure-60 11million tons wheat stocks of Sindh Food Department were fumigated under the supervision of FQSRI.

ACCREDITATION OF SARC LABS

Accreditation to ISO 17025

- SARC laboratory has applied for Accreditation of ISO 17025 to PNAC. Application is executed with a wider scope of around 40 test procedure.
- Most of the labs has extensively participated different Proficiency schemes of Bipea & AACC on monthly basis. Around 85 to 90% percent clearances in the tests were obtained. Inter Lab comparisons (ILCs) were also conducted for the labs that have no PT provider that includes their testing scopes in their provided services.
- A thorough activity of monthly internal audits against different quality & technical clauses of ISO 17025 were conducted. External audit activities were also executed.
- Calibration of Equipments was also renewed.
- The quality and technical manual and others system documents including PT summaries, Management Review Meetings, Internal Meetings, and Audit activities all documents are being evaluated by the PNAC assessor.

RESEARCH & TRAINING AT MULTAN

Research Highlights

- Biological control agents rearing lab facilitated the small farmers of the Multan area by providing 4851 *Trichogramma* cards to 70 farmers. Moreover, 2600 *Chrysoperla* cards were also delivered to 62 farmers.
- A coordinated project on *Integrated Management Strategies for Fruit Flies* was executed.
- Comparative study of integrated pest management strategies in two different cotton varieties (*BS-52* and *BS-013*) was conducted.
- Conducted the trials on comparative control measures of biological and chemical control of sucking pest in citrus orchards in Multan.
- Conducted the trial to develop resistance in *Chrysoperla carnea* against spinosad insecticide.
- The common green lacewing *Chrysoperla carnea* is a key biological control agent employed in integrated pest management (IPM) programs for managing various insect pests. Spinosad is used for the management of pests in ornamental plants, fruit trees, vegetable and field crops all over the world, including Pakistan. A field- collected population of *C. carnea* was selected with spinosad and fitness costs and realized heritability were investigated.



Figure-61 Demonstration of integrated fruit fly management strategies



Figure-62 Field Training of integrated fruit fly management strategies

After selection for five generations, *C. carnea* developed 12.65- and 73.37-fold resistance to spinosad compared to the field and UNSEL populations. The resistant population had a relative fitness of 1.47, with substantially higher emergence rate of healthy adults, fecundity and hatchability and shorter larval

duration, pupal duration, and development time as compared to a susceptible laboratory population. Mean relative growth rate of larvae, intrinsic rate of natural population increase and biotic potential was higher for the spinosad-selected population compared to the susceptible laboratory population. *Chrysoperla* species are known to show resistance to insecticides which makes the predator compatible with most IPM systems. The realized heritability (h^2) value of spinosad resistance was 0.37 in spinosad-selected population of *Chrysoperla carnea*.

Training Activities

- “*Biological Control of Agricultural Pests and Diseases*” from 19-21 March, 2014, organized by Agriculture Poly-Technique Institute, at National Agricultural Research Centre, Islamabad. (Pakistan).
- Developed an Urdu Broacher entitled “*Phal ke Makhi Ka Tadaruk*” in collaboration with Insect Pest Management Programme NARC, Under the RADP Sub- Project “Integrated management Strategies for Fruit flies.
- Demonstration of Small-Scale Hot Water Treatment Unit on July 14, 2014 at Mango Research Institute, Multan.
- Wheat Straw Chopper demonstration was held on May 9, 2014. The demonstration was jointly organized by PARC Research and Training Station, Multan and relevant institutes of National Agricultural Research Centre, Islamabad.
- During the reporting period, 974 group of farmers, 17 individual farmers and 73 students were trained. Moreover, 23 students also got their internship.



Figure-63 Demonstration of wheat straw chopper